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ELECTRICITY AT THE BRITISH ASSOCIATION.

THE Glasgow Meeting of the British Association will long be remembered as one that has yielded some of the most fruitful and important contributions ever made to the physical sciences. Unquestionably the most novel and valuable paper was the short one by the Rev. Dr. Ker, who announced the surprising discovery of the rotation of the plane of polarisation of light by simple reflection from a polished magnetic pole. This truly magnificent discovery, as Sir W. Thomson described it, quickly follows Dr. Ker's now well-known paper on the "Influence of Electrification on the Plane of Polarisation of Light." Those who have not tried to repeat Dr. Ker's experiments can scarcely form any idea of the exquisite delicacy of manipulation required to reveal the effect he has discovered, nor how carefully the experimenter has to pick his way amid an entanglement of difficulties that make it amazing how the effect was first seen. We have every reason to hope that Dr. Ker's latest discovery will be confirmed by other observers. The experiment, however, is so beset with difficulties, that those who repeat it must not expect success at first; indeed, considering the state of knowledge at his time, we should not wonder if Faraday had looked for it in vain. As Professor Stokes observed, after hearing Dr. Ker's paper, "that there should be an effect at all of this nature, was a most remarkable thing, and he had no doubt it would lead to much further insight into certain molecular processes than we now possess."

Another most important electrical contribution was Professor Clerk Maxwell's Report of the Committee appointed to test the exactness of Ohm's law experimentally. The result of these experiments, conducted in the Cavendish Laboratory by a most able and rising young physicist, Mr. Chrystal, is to show that Ohm's law is rigidly true, so far as may be inferred from the experimental methods tried. Without here entering into particulars of this valuable Report, it may briefly be stated that three different methods of experiment were tried, and all yielded the same result, which may be stated thus:—"If a conductor of iron, platinum, or German silver, of one square centimetre in section has a resistance of one Ohm for infinitely small currents, its resistance when acted on by an E. M. F. of one volt (provided its temperature is kept the same) is not altered by so much as the millionth of a millionth part." This searching test encourages us to believe, as Professor Maxwell says, that the simplicity of an empirical law, such as Ohm's, may sometimes be an argument for its exactness.

Other valuable electrical papers were also read, notably two by Mr. Lodge, which we hope soon to reproduce, a paper by Professors Ayrton and Perry, and one by Sir W. Thomson, on the contact theory of electricity; for these our readers are referred to the present and subsequent numbers of this Journal.

We must omit as beyond the province of this Journal a description of the extremely interesting papers by Professor Stokes on Metallic Reflection, by Professor Osborne Reynolds on Vortex Rings in Liquids, and the very valuable paper by a young Dutch physicist, M. Janssen (no relation of the great Paris astronomer), on nitrous oxide in the gaseous and liquid states; the particulars of these and other important contributions will doubtless be found in our contemporary, *Nature*.

It is, however, always a source of regret to a large number of absentees that fuller records of the papers and the more valuable portion of the discussions thereon are not preserved in some more careful and systematic way. A competent reporter might be attached to each section, and under the guidance of the Secretaries of the Section verbatim records might thus be taken of all the best papers and speeches. The many valuable contributions made by Sir W. Thomson, for example, which are generally delivered extempore at the Association, might in this way be quickly given to the scientific public, and its author spared much subsequent trouble. We trust that before long the Association will find ways and means to carry out some such scheme as we have indicated, and thus largely to extend the good it already does, and incur the gratitude of the vast number of scientific men who are unable to attend its meetings.

W. F. B.

NEW RESEARCHES ON THE ELECTRICAL PHENOMENA OF VENUS'S FLY-TRAP.

IT it known that this carnivorous plant (*Dionæa Muscipula*) has a leaf consisting of two somewhat semi-circular portions, which, on stimulation, are folded together. It will be remembered that Dr. Burdon Sanderson found the leaf to have an electro-motive action, like muscles; and, as in muscles, that there was a negative variation of the current when contraction took place; further, he observed what corresponded to the period of

latent stimulation of the muscle and the electrotonus of the nerve.

The subject has since been studied by others, and recently, as we learn from *Naturforscher*, by M. Hermann Munk. Dr. Sanderson's observations were made on the leaves cut off;* M. Munk, on the other hand, has applied the unpolarisable electrodes to the *uninjured* leaves, and studied the distribution of tension. The phenomena which occur in this case we shall now shortly recount.

If the under surface of the leaf be first studied thus, a current appears in (say) *upward* direction, *i.e.*, flowing in the leaf from the end of the petiole or leafstalk (call it the *fore end* of the leaf), to the free end or point of the leaf (which may be called the *hinder end*). Points situated similarly on the two halves of the leaf are homogeneous, hence on the two sides of the midrib all is symmetrical.

Conceive the midrib divided into two unequal parts, a shorter hinder part and a longer fore part; then in each of these parts every point nearer the inner end is positive to every more distant point. The most positive point of the midrib lies about the fore end of its hindermost third, and with increasing distance from this point the positivity decreases towards both ends.

Suppose lines drawn on the surface of a half-leaf at right angles to the midrib; and call these, *cross lines* of the leaf. Every point of such a cross line proves negative to the corresponding point of the midrib; and regularly the negativity of these points increases first to a maximum, and then, on to the outer leaf-border, decreases. The most negative point of the cross line never coincides with the middle of the line, but is always nearer the leaf-border than the midrib.

By connecting the most negative points of all the sections, we have a principal line of length *(Hauptlängslinie)* nearly parallel to that of the midrib. All points in this line are homogeneous. So also are related points of other lines of length running parallel to the midrib, and lying inwards from the principal length-line. Of the middle parts of two cross lines, which are both in the fore or both in the hinder halves of the leaf-halves, the middle nearer to the fore or to the hinder leaf-border respectively, is always positive to the more distant middle, and the force, downward in the former case, upward in the latter, increases with the width of span of the arch. The principal length-line, then, is the sum of the most negative points of each leaf-half, while, in opposition, is the most positive point of the leaf at the fore end of the hindermost third of the midrib. And, as in the whole leaf, all is symmetrical on the two sides of the midrib, so in each leaf-half all is symmetrical on the two sides of the middle cross-line. The complete symmetry of the leaf seems to be disturbed only in that the most positive point in the midrib is displaced back from the middle.

The examination of the upper surface of the leaf offers great difficulties, owing to its sensitiveness. These having been overcome, it is found that the same distribution of tensions prevails as on the under surface. Indeed, between two similarly situated points on the two surfaces there is no difference of tension, so that it may be assumed that the absolute amount of tensions on the two surfaces is the same. All these electromotive actions of the leaf of Dionæa are a life-property of it, and gradually decrease as it gradually dies. They are further dependent on the state of nutrition of its leaf, and its fulness and vigour of life.

The absolute amount of the force is considerable. The difference of tension between a point in the region of the principal line of length, and a point in the hinder half of the midrib, is about 0·04—0·05 of a Daniell, and may even rise to 0·07D. Between other points of the leaf smaller values are had.

M. Munk proceeds to inquire as to the source of the electro-motive actions. He considers the forces must reside in the interior of the leaf, and cannot arise from heterogeneity of surface. By way of preliminary experiment, he had combinations of zinc-copper plates prepared, which, immersed in a conducting liquid, gave tensions on their surface similar to those found on the surface of the leaf. Thus a representation may be given of the electro-motive forces probably operating within the leaf. The combination of two flat zinc cylinders, with coppered exterior, their bases turned toward each other, and the outer parts obliquely cut away, so that in the middle an obtuse angle is formed, and the whole immersed in a conducting liquid, represents approximately the electro-motive forces in question. In place of these two flat cylinders, conceive many small narrow cylinders of the same kind, giving much the same electro-motive force. Guided by these preliminary observations M. Munk successively excludes, as possible seat of the electric forces, the disc-glands, the star-like hairs, the fibro-vascular cords, and the epidermis, so that there remains only the parenchyma; with regard to which he concludes that the roughly cylindrical cells of the parenchyma in the halves of the leaf, and that of the midribs, are endowed with forces of such a kind, that the positive electricity is driven from the middle of the cell to each of the two poles, which are positive poles to the middle.

The mechanical movements of the plant are of two kinds; stimulation movements, and resorption movements. In the former, the leaf closes very quickly after stimulation, within a minute or so, all parts moving simultaneously. In a few hours it begins to open again, and is quite open after 24–36 hours. It is then susceptible of further stimulation. The resorption movement, on the other hand, is more rare, and occurs when a small piece of flesh, albumen, or the like, is carefully laid on the leaf-surface, avoiding the sensitive hairs. The closure which follows is very slow, not beginning for some hours, and being completed only in 1–2 days. The movements of the two halves are irregular and unsimultaneous, and depend on the place of contact; from which they spread outwards. The re-opening begins after several days, and takes several days to be completed; and during this time the

* This statement, we learn from Dr. Sanderson, is incorrect. He used leaves *on the plant* as well as separated. It is but fair to point out that M. Munk has confirmed all the statements made by Dr. Sanderson as recorded in Proceedings of Royal Society. A notice of Dr. Sanderson's recent paper to the British Association appears in another column, p. 261.

leaf is not, or is very little, susceptible of either stimulation or resorption movements. The leaf may die after one such resorption movement, and two or three always prove fatal to it; it opens no more.

M. Munk has occupied himself with the stimulation movement. It appears that the upper parts of the parenchyma of the leaf-halves and the upper midrib parenchyma, or at least its upper portion, are the stimulable parts; they may be stimulated by mechanical seizure, or removal of water in certain amount or with certain rapidity. M. Munk says the stimulation is propagated immediately over the whole parenchyma, and it relaxes. The relaxation occurs, as in Mimosa, through a flow of water from the interior of the stimulable parenchyma-cells, whereby the stiffness of the cells is diminished, and a good part of the escaping liquid goes into the parenchyma of the unstimulable parts. This is necessarily followed by movement, as the author explains.

We now come to the electrical phenomena in stimulation, of which Dr. Sanderson said that they presented a negative variation similar to that of the muscle-current. The electrodes were placed on the under surface of the midrib, as being the only part of the leaf which, during movement of the latter, does not alter in position. On stimulation through movement of the sensitive hair, there occurs, not a simple negative variation, but, as the author expresses it, a positive variation with negative primary impulse *(Vorschlag)*, which he calls double variation. This electrical phenomenon occurs even when, notwithstanding stimulation, there is no movement of the leaf. The latter circumstance renders possible an examination also of the leaf parenchyma; and the same double variation is here observed.

As to the explanation of this double variation, the supposition, that all the cells pass first through a negative then through a positive variation, is to be rejected; the process is rather (the author thinks) that through stimulation the cells of the upper halves of the half-leaf parenchyma and of the upper midrib parenchyma experience a negative variation, those of the under halves of the half-leaf parenchyma and of the under midrib parenchyma a positive, that is, the negativity of the middle of the cells to their poles increases in the former cells, on stimulation, and decreases in the latter.

As regards time-relations, the phenomena of variation are fully run through, when the stimulation-movement begins.

A review of Count Du Moncel's important work on applications of electricity lately appeared in our columns. We willingly make known a desire expressed by the Count, that those in this country who may have new inventions relating to the subject in question (to which he has devoted much attention) would send him information regarding them; addressing, "à Lebisey, près Caen." It need hardly be pointed out that the benefaction in such a case is mutual.

SPECIAL LOAN COLLECTION OF SCIENTIFIC APPARATUS.

IV.

THE instruments already referred to under the head of recording telegraphs are those which denote the Morse code; but in addition there are some valuable and useful instruments which are termed "type-printers." Amongst the foremost of these are specimens of the Hughes Type-printing Instrument (1545), exhibited by the Postmaster-General, and which is thus described—"A purely synchronous instrument. The instruments at each end of the line are timed to run as nearly as possible at the same speed, and regulated by a spring vibrating in a circle. The type-wheel revolves continually, and does not stop during the printing of a letter. One current only is necessary for the latter operation, which is performed by the wheel-work liberated by an electro-magnet of peculiar construction placed in the line circuit. Each time a letter is printed the type-wheel, if out of time, is corrected, that is, moved backwards or forwards on its axis, without disturbing the train of wheels, so as to be synchronous with the instrument at the distant station."

The Hughes instrument has been considered the most successful of all type-printing instruments, and as regards its mechanism shows a marvel of ingenuity. It is very largely used on the Continent, and by our own Submarine Company, who work many of the Continental circuits with it. It was used in this country by the United Kingdom Telegraph Company, who purchased the patent. Its use was for some time continued by the Post Office after the transfer of the telegraphs; but latterly it has been abandoned, and at the present time no circuits are worked on this system. The abandonment is not due in any way to the instrument itself, but apparently to the difficulty of obtaining sufficiently skilful staff, and to the undesirability of having too great a variety of instruments in the service.

Of early forms of type-printing instruments, we find specimens of Wheatstone's (1543), of the year 1841; and of Theiler's (1544), of 1854, thus described:—"Two currents are required for each letter, one to start the instrument and another to print. The type-wheel returns to zero after the printing of each letter; the sending and receiving instruments are made to act in unison, the speed being regulated by a milled nut, which is fixed on an arm attached to the anchor of the escapement."

In 1863-64 Theiler brought out a "step by step" type-printer (1546), which differs from the preceding. "The type-wheel fixed on the axle of the escapement is controlled by reversals, and the printing is performed by the wheel-work, which is brought into action by an electro-magnet, the local battery circuit of the latter being closed by a vibratory arrangement, which does not close the local circuit of this magnet until the type-wheel is stopped at any particular letter."

The Dujardin type-printer (1547), which was used for a short period between London and Edinburgh in 1865, which differs somewhat from the others—the instrument is step by step, and in which the escapement is controlled by reversals,

the electro-magnets acting on the anchor of the escapement being worked by a polarised relay in the line circuit, and a local battery. The operation of printing is performed by an electro-magnet, the local battery circuit of which is closed by the anchor of the escapement at the end of each oscillation. When no key is depressed, and the apparatus is running, the short currents passing through the printing magnet are insufficient to cause it to attract its armature; but when a key is depressed and the type-wheel stopped at any particular letter, the printing magnet attracts its armature, and an impression is made. An electro-magnetic "cut-off" arrangement is used in connection with the printing magnet, by which the blow struck is always equal in duration, whether the key be held down for a longer or shorter time. The operation of printing is, as in the Hughes, performed at both sending and receiving instruments.

The ordinary A. B. C. instrument of Wheatstone has been adapted equally to printing in type; but the delicacy of the instrument has hitherto prevented its introduction. The arrangements are such that the instruments can be used readily for either a "printer" or "A. B. C."

An instrument was largely introduced into America some years since, and termed the "Gold Stock" printing instrument. A transmitter was placed at the central station, and receiving instruments at offices wherever desired. The transmitter was so arranged that the various receiving instruments were equally actuated, and messages were received at each office without any other attention being necessary than the occasional winding of the instrument. It was used for the frequent transmission of the various changes in the stock, share, and other markets, to not only offices and individuals, but also to newspapers. This instrument was introduced into London by the Exchange Telegraph Company, and subsequently largely improved upon. Communications are now established with it to many points throughout the City, and newspapers and individuals are kept closely informed of any variation in the stock and share lists, and any changes in the markets.

The only instrument of this class exhibited is one by the Messrs. Siemens.

Of the alphabetical form of instrument many specimens may be seen, from the early historical ones of Cooke and Wheatstone to the present modernised form so extensively used now for private wires. At 1548 (1849-1850) may be seen the early forms of these. The first, a step-by-step instrument. The letters of the alphabet are arranged round a paper disc fixed on the axle of an escapement-wheel. The letters are presented at an opening in the front of the case. The escapement is similar to the "*échappement à cheville*," and is controlled by an electro-magnet. There are as many teeth in the escapement-wheel as there are letters in the revolving disc; the latter moves from one letter to the following for each current sent. The train-work of wheel-work is actuated by a main-spring. In the two other instruments the revolving disc is replaced by a pointer, and in 1550 the current used is magneto-electric, the instrument being provided with a commutator, so constructed that the currents are in the same direction.

The council of King's College, London, exhibit a variety of Wheatstone's A B C. instruments, which exhibit the several improvements made by him.

Some forms of the modern A B C. are also exhibited by Messrs. Siemens; and at 1690a Deschien's "double-indexed telegraph-post, with alphabetical receiver, indicator, and printer at will, manipulator (Chambrier's system) working in any direction," may be noted for its excellence of manufacture.

The acoustic form of instrument is exemplified by "Bright's Bells," 1855, with relay (1525) used by the Magnetic Telegraph Company. In this instrument the single-needle alphabet is produced by striking two bells of different notes, the hammers being actuated by electro-magnets worked by a relay and local battery. The relay is double-acting, and consists of two electro-magnetic bobbins placed side by side, their ends being furnished with pole-pieces turning inwards. Between these pole-pieces at each end of the bobbins the ends of permanently-magnetised needles pivoted on vertical axles play; these needles are so placed as regards their polarity, that a current in one direction moves the needle which closes the local circuit of the right-hand bell, and a current in the opposite direction moves the other needle which closes the local circuit of the left-hand bell. The signalling key used with this instrument is similar to that used with Highton's single needle. This instrument superseded Henley's magneto-electric system.

At 1526 may be seen a model of Bright's Direct Bell Instrument (1870), in which the bells are struck by hammers attached to the magnetic needles of the relay.

At 1565, exhibited by the Postmaster-General, is a "Pony Sounder," which is thus described—"This instrument is of American origin; it is used instead of the ink-writer on some of the lines of the Postal Telegraph Department, the dots and dashes of the Morse Alphabet being read by sound from the clicking of the armature lever, instead of from the paper band of the recording instrument; it possesses the advantage of not fatiguing the eye of the operator, and allows him perfect freedom for writing the message." Its use in this country is on the increase, as there are many points in its favour; in America it is almost the universal instrument, for of all the apparatus used there the Sounder occupies about four-fifths of the number.

Several specimens of sounders may be seen, used for military service; these are light and portable, and the sounder and key being in one small case, contributes not only to the lightness and handiness of the instrument, but also to its utility.

Of various instruments of an "acoustic" character, are classed alarums and bells for railway and domestic purposes, but these must be dealt with further on.

M. Pouyer Quertier is at the head of a French company being formed with a capital of £132,000 for laying a cable between Paris and New York.

A SUMMARY OF ELECTRICAL SCIENCE AT THE BRITISH ASSOCIATION.

The meeting of the British Association, which has just been concluded, was especially a characteristic one for two reasons. Firstly, it included a larger number of foreign members than on any previous occasion, there being present no fewer than twenty-two foreigners of distinction; and, secondly, the meetings in Section A devoted to Mathematical and Physical Science were from first to last so well attended, that there was always a small crowd round the entrances, unable to gain admission, although the space behind the lecture-table, usually set apart for the Sectional Committee and general officers of the Association, as well as all the gangways, were crowded to inconvenience. That this should be the case, notwithstanding the "drawing" attractions outside, due to papers in other sections by Sir Wyville Thomson, Lieutenant Cameron, and the Duke of Argyll, as well as the animated discussion in Section D, which followed Professor Bafrett's paper upon *Abnormal Conditions of Mind*—dealing as it did with the so-called phenomena of Spiritualism—shows that Physical Science is making rapid strides in popular favour, and gives great encouragement to the extension of sound technical education, both in the Universities and in the great manufacturing centres.

At no previous meeting of the British Association do we remember so large a share of the business in Section A devoted to Electricity and Magnetism. The meeting at Bristol last year was singularly deficient in this respect, as we pointed out at the time, but the Section under the presidency of Sir William Thomson has this year more than made up the deficiency, there having been read no fewer than sixteen papers upon Electrical and kindred subjects.

In his inaugural address Sir William Thomson passed a high eulogium upon the physicists of America, and spoke in glowing terms of their "true scientific spirit and devotion, the originality, the inventiveness, the patient, persevering thoroughness which characterised their work, and their generous open-mindedness and sympathy, from which the great things of science come." He referred to the zeal and enterprise of the United States Telegraphic Department, and showed to his hearers an instrument, or, more correctly speaking, a pair of instruments, which he justly characterised as "the greatest by far of all the marvels of the Electric Telegraph," the electric articulation Telephone of Mr. Graham Bell, a native of Edinburgh, but a naturalised citizen of the United States. With this instrument Sir William Thomson heard the words, "To be or not to be * * * * there's the rub;" and "the Americans in London have resolved to celebrate the coming 4th of July," as well as other sentences involving still longer words, which were shouted into a mouth-piece or transmitting instrument of the simplest possible construction. It consists of a membrane stretched vertically across a circular frame of brass, and carrying at its centre a thin oblong piece of soft iron, which vibrates with the membrane in front of the poles of a horse-shoe electro-magnet, fixed in a horizontal position, and having its wire in circuit with the receiving instrument or telephone, which is nothing more than a vertical iron-encased electro-magnet (similar to those which formed the subject of a paper by Mr. C. V. Walker, read before the Society of Telegraph Engineers in December last), and having an armature of sheet iron of the thickness of cartridge paper screwed at its edge to the top of the outer casing, but touching it at no other spot.

The vibrations of the membrane due to the voice cause the soft iron inductor to vibrate in front of the electro-magnet, thus inducing a set of induced currents in the wire surrounding it, and therefore in that of the receiving instrument at the distant station; and a corresponding vibration is set up in the thin plate of iron or armature, sufficient to produce sonorous vibrations audible to the ear, by which articulated words can be distinctly recognised. The essential peculiarity in this instrument and that which makes it differ from previous attempts to obtain the same result consists in the fact that the communicated vibrations are not only synchronous with those of the transmitting membrane, but they are at the same time similar in quality, due to variations in the amplitude, and therefore to the inductive influence of the vibrating inductor.

We shall on an early occasion give an illustrated description of these two instruments.

The very first communication that came before the Association in Section A was the Report of the Committee appointed to investigate the correctness of Ohm's law, an investigation the result of which touches the very life-blood of all electrical measurements, and is the corner-stone upon which the superstructure of Telegraph Engineering rests.

It is satisfactory to learn from this Report that after a series of most searching tests made in the Cavendish Laboratory of Cambridge University, by Mr. G. Chrystal, with the co-operation of Professor Clerk Maxwell, the absolute correctness of Ohm's law has been established without the shadow of a doubt. In some of the experiments currents were employed of such a strength as to heat the fine wires to redness; but even in these exaggerated cases no deviation from Ohm's law could be detected. The Report is a highly interesting and instructive one, and the experimental test recorded in it will well repay very careful perusal.

Sir William Thomson read a very interesting paper, which he illustrated experimentally, on the "Influence of Stress upon the Magnetisation of Iron." By means of a minute reflecting magnetometer he made apparent to a large audience the magnetisation of a soft iron wire, suspended from the roof of the laboratory, adding weights to a scale-pan attached to its lowest extremity. So sensitive was the magnetometer he employed, although made in the simplest possible manner, that he was able to exhibit the magnetisation of soft iron wire caused by the strain due to drawing it between the fingers, which to a superficial observer would have been a convincing proof of the existence of animal magnetism, for a piece of iron was magnetised by the ordinary process of

"*single touch*," in which the inducting magnet was replaced by the finger and thumb, Sir William Thomson having made it perfectly clear that the magnetisation was due entirely to the effects of stress applied to the wire, while held in the direction of the magnetic inclination or dip.

One of the most beautiful demonstrations since Faraday's celebrated discovery of the rotation of the plane of polarisation of a beam of light under the influence of magnetism was made by Dr. Ker, of Glasgow, in which he showed that the plane of polarisation is rotated when a beam of polarised light is reflected from the face of a magnetic pole. [We shall return to this.[

Dr. Ker's paper was followed by two interesting communications from Mr. Oliver J. Lodge, B.Sc., of University College, London, upon a mechanical method of illustrating Electrical Phenomena, according to Professor Clerk Maxwell's theory, and which is contained in his work upon Electricity. In the first of these papers Mr. Lodge described a model for illustrating the laws of Conduction and Induction, and which consists of an endless cord passing with friction through beads supported on elastic strings; by varying the relation between the friction and the elasticity of the different parts it can be made to exhibit very completely the phenomena observed, when an electro-motive force is made to act (1) between the ends of a metallic wire, (2) through a liquid electrolyte exhibiting the phenomenon of electric polarisation, (3) in an accumulator with a perfectly insulating dielectric, (4) across a homogeneous dielectric with a slight conducting power, and (5) across a stratified dielectric in which a succession of residual charges is possible.

The cord sliding through the beads may be taken to represent a current of electricity, and a weight suspended from one end of it would represent a source of electro-motive force: the beads would represent the bounding surfaces of the various dielectric strata through which a current is passing, and the friction they offer to the string would represent the resistances offered to the current in its passage through the medium. The elasticity of the strings which support the beads is analogous to the equilibrating tendency of bodies at different electrical potentials to assume the same electrical state when brought near to one another, which might show itself by disruptive discharge represented by the breaking of the elastic thread, or by slow conduction or "leakage," which would be represented by the gradual sliding back of the beads.

The model described in this paper, as well the modified form of it referred to in the second communication, and which is intended to illustrate the phenomena of thermo-electricity, display much thoughtful labour and ingenuity, but it is impossible without the aid of diagrams to convey an intelligible idea of their construction. We hope, however, to be able to refer again to this subject on a future occasion.

Professor Barrett presented a preliminary report of the Committee appointed to investigate the magnetisation of iron, nickel, and cobalt, and described his very beautiful method of measuring minute increments or decrements of length due to the magnetisation of these metals; the results of Professor Barrett's further researches in this direction will be laid before the Physical Society, and will be reported in these columns in due course.

The British Association may well be congratulated upon the Glasgow Meeting, which owes not a little of its success to the able presidency in Section A of Sir William Thomson, who in addition to presiding over the Section, and joining in almost every discussion, contributed no fewer than thirteen papers to the Association.

VOLTAIC ELECTRICITY.

BY PROFESSOR TYNDALL, D.C.L., LL.D., F.R.S.

LECTURE VII.

(Conclusion of the Course from page 233.)

FARADAY'S researches proved that every change of the magnetic condition of the space near a secondary coil, or within it, produces an induced current in the coil. If the change be an augmentation of magnetism, the current is in one direction; if it be a diminution of magnetism, the current is in the opposite direction.

When a long secondary coil surrounds a primary coil with a core of iron, by breaking and making the circuit of the primary in rapid succession, a series of powerful discharges may be obtained. An automatic apparatus is usually employed to make and break the circuit.

Such induction coils have been constructed with great skill by Ruhmkorff, and are therefore sometimes called Ruhmkorff's coils. The power of a coil depends mainly on the perfection of the insulation of its coils. The induced currents in a Ruhmkorff's coil may possess thousands of times the electro-motive force of the primary which excites them. They are able, for example, to overleap as sparks, distances thousands of times greater than that possible to the primary. In these coils the battery is the source of power, but similar effects are obtained with magnets alone and rotating coils.

In 1833 a machine was constructed by Saxton for the more copious development of magneto-electric currents. In it copper wire coils, within which were placed cores of iron, were caused to rotate before the poles of a powerful magnet. On the approach of a coil to one of the poles of the magnet, a powerful current, whose direction depended on the nature of the pole, was induced in the coil. When the coil retreated from the magnetic pole, a current in the opposite direction was induced. By means of a commutator, which reversed one of the induced currents at the proper moment, the opposite currents were caused to flow in the same direction. The cores of soft iron and their associated coils constitute what is called an armature. In Saxton's armature the coils were wound transversely to the iron cores. But by winding his coils longitudinally, or parallel to the axis of the core, and placing the armature so formed between the poles of a series of horse-shoe magnets, Siemens obtained magneto-electric currents much more powerful than those of Saxton.

Things were in this state when, in 1866, Wilde made an important addition to our knowledge of magneto-electricity. He conducted the current obtained by means of Siemens's armature round an electro-magnet, and found that the magnetism thus excited was far greater than that of the entire series of steel magnets employed to generate the magneto-electric current.

But Wilde went further. Forming his electro-magnet from a large plate of iron, and placing between its long poles a corresponding long armature, similar in shape and construction to that of the magneto-electric machine, he obtained from this second armature currents of enormously greater power than those obtainable from the first. These currents could in their turn be sent round a second electro-magnet, formed from a larger plate of iron. Furnished with a rotating armature, this second electro-magnet produced effects previously unknown. Rods of iron a quarter of an inch in thickness were fused by the currents; which were also found competent, when discharged between carbon terminals, to produce a light of intolerable brilliancy.

The next great step in magneto-electricity was made simultaneously by Dr. Werner Siemens and Sir Charles Wheatstone. Expressed generally, this discovery consists in exalting, by means of its own action, to a high pitch of intensity, an infinitesimal amount of magnetism.

Conceive an electro-magnetic core with a very small amount of residual magnetism, which is never wholly absent when iron has been once magnetised. Let a secondary coil, with cores of soft iron, rotate before the poles of such a magnet. Exceedingly feeble induced currents will circulate in the secondary coil. Let these induced currents, instead of being carried away, be sent round the electro-magnet which produced them; its magnetism will be thereby exalted. It is then in a condition to produce still stronger currents. These also being sent round the magnet, raise its magnetism still higher, a more copious production of induced currents being the consequence. Thus by a series of interactions between the electro-magnet and the secondary helix, each in turn exalting the other, the electro-magnet is raised from a state of almost perfect neutrality to one of intense magnetisation.

When the magnet has been raised to this condition, other coils than those employed to magnetise it may be caused to rotate before, or between its poles; the currents from these coils may be carried away and made use of, for magnetisation, for chemical decomposition, or for the electric light.

The first magneto-electric machine used to produce a light sufficiently intense for lighthouses was constructed by Mr. Holmes. In it permanent steel-magnets and rotating helices were employed. He also constructed a very powerful machine on the principle of Siemens and Wheatstone. To these a beautiful form of electro-magnetic machine has more recently been added by Gramme.

When the voltaic current is sent through a single primary coil, the primary current excites in the wire which carries it a secondary current opposed in direction to the primary. When the primary current is broken, a secondary current of momentary duration, and having the same direction as the vanishing primary, is evoked in the coil. Each of these two currents has been called by Faraday an "extra-current." The spark obtained on breaking the primary circuit is augmented in brilliancy and power by the extra-current. The shock of the extra-current was discovered by William Jenkin; but that both spark and shock are due to an extra-current was first proved by Faraday in 1834.

If a second circuit be associated with the primary; if, for example, two covered wires are wound round the same reel; on making one of them a primary circuit we have the brilliant spark due to the extra-current, as long as the ends of the second coil remain unconnected. But the moment they are connected, the extra-current in the primary circuit disappears; and there is an instant reduction in the brilliancy of the spark.

The intensity of the secondary current—its "discharging distance," for example—depends upon the rapidity with which the primary is interrupted. By the passage of small particles between the severed terminals of a circuit the current may be kept up for a short time after the terminals have been disunited. A gradual dying away of the primary is the consequence. But to produce the the maximum secondary intensity, it is necessary that the primary should be extinguished at once.

This is very effectually accomplished if the primary be broken between the poles of a strong magnet. The secondary spark may be thus made to overleap distances, vast in comparison with those possible to it when the rupture of contact occurs far away from the magnetic poles. The magnet quenches immediately the stream of particles which accompany the spark. Thus, instead of being spread over a very sensible interval, the whole power of the primary is concentrated in an instant of time. This concentration is announced by the loudness of the report of the primary spark.

This augmentation of loudness was first observed by Page; it was explained by Rijke, who also exalted in the way here indicated the discharge of the secondary coil.

The luminous discharge is to all intents and purposes an electric current, and is acted on by a magnet like a wire carrying a current. The flexibility of the luminous current in rarefied gases enables the magnet to act upon it in a manner peculiarly interesting and instructive. Placing a tube through which the luminous discharge is passing between the poles of an electro-magnet, by exciting the magnet the stream of light may be either deflected or wholly extinguished. In the latter case by interrupting the current passing round the magnet, or by lifting the tube out of the magnetic field, the luminous discharge is restored.

In certain cases when the luminous discharge consist simply of a feeble glow, the supervention of the magnetic force draws a series of strongly illuminated strata from the positive terminal of the vacuum tube; when the magnetism is interrupted, these strata retreat again in succession, as if swallowed up by the positive pole.

When the light surrounding the negative terminal is subjected to a magnet, it ranges itself exactly along the lines of magnetic force; the

light at the positive terminal shows no such action. This discovery is due to Plücker.

(The experimental nature of the course did not permit of the subject of telegraphy proper being introduced, but some notes on it were supplied by Dr. Tyndall to his hearers).

Notes.

The Hell Gate Mine, New York, was fired at 2·50 on the afternoon of September 24. General Newton considered the explosion satisfactory. There were 52,206 lbs. of explosives (dynamite, vulcan, and rendrock powder) in the mine, in 4,462 charged holes. About two pounds of powder were used to one of dynamite. Twenty-three batteries, aggregating 960 cells, were used in the explosion, their distance from the mine being 650 feet. Guard boats were placed at a similar distance from the mine to prevent vessels approaching, and a large police detachment was on duty to preserve order in the large crowds that assembled. There was scarcely any detonation, and the vibration of the neighbouring ground was very slight. No commotion of the atmosphere was felt, and neither sound nor shock (according to one account) at points five miles away, while another account says the explosion was heard at a distance of ten miles. Thus has been successfully concluded the seven years' work of opening a navigable passage from Long Island Sound into New York Harbour. It is estimated that about 30,000 cubic feet of broken rock are left under water, and this will have to be removed by dredging so as to secure a channel 26 feet in depth.

Some suggestions forwarded by Messrs. Nicholls and Arnold and Colonel Grant to the Brussels Geographical Conference, with regard to the idea of introducing the telegraph into the African Continent from Egypt overland to the Cape of Good Hope, have been collected in a small pamphlet. There is little doubt that Africa offers as many facilities for construction of a line as Australia or America—indeed, greater facilities; and the principal obstacles seem to lie in the nature of the population. At present the Egyptian wire extends to Khartoum, which is 1,260 miles from Alexandria, and this is being extended to Gondokoro, 700 miles further on. "Hence," says Mr. Arnold, "the route to King M'tesa's capital is within practical control, the distance being about 230 miles. King M'tesa's city makes a safe and central station, and thence the wire should be taken under the Victoria Lake, which gives us 200 miles more of waterwork to Muanza. Hence it should go overland by Speke's old route to Kazĕ, which is about 150 miles off, and thence should bifurcate, on fairly secure roads, to Ujiji and Bagamoyo (Zanzibar). Having thus picked up two commercial emporiums, it would pass down Tanganyika, and go to Bemba and Lobisa overland to Lake Nyassa, where it is to be submarine again till it reaches the new town of Livingstonia. Hence it would safely proceed down the Shirè and Zambezi rivers to the sea, where a short ocean-line would connect it with Delagoa Bay, or, better still, Port Natal; or it might yet more cheaply pass overland from Lake Nyassa to the Transvaal frontier. The distance to be covered between the Egyptian and colonial ends is about 2,700 miles, but out of this at least 1,500 may perhaps be laid in the beds of rivers and lakes. There is, however, no necessity for expensive insulated cables; a simple railway wire stretched openly from tree to tree, or upon poles, may be carried from Khartoum to the Limpopo; and once established, will be maintained by small subsidies to the chiefs. Commerce and profit will soon protect what they depend on; stations will arise like beads on a string, and the aforesaid subsidies—with the fear of 'fetish' and travelling inspectors—will keep the line open as surely as all others have been maintained across barbarous countries."

Continuing his interesting inquiry into the cause of motion of the radiometer, Father Delsaulx (*Nature*, 21st September) gives experimental reasons for believing that the inner surface of the globe is electrified positively. The direct rotation is a necessary consequence of the attractions and repulsions which this positive electricity exerts on the free electricity of the vanes. This rotation continues when the radiometer is surrounded by light, because a perfectly homogeneous layer of electricity on the inner surface is almost impossible. The inverse rotation occurs in two circumstances—1. When the instrument, having been exposed to radiation, which produces a direct rotation, is allowed to cool slowly. 2. When the radiometer at the ordinary temperature is cooled suddenly; *e.g.*, by moistening it with ether. Both of these cases he finds in harmony with his electrical theory, but for further details we must refer to his letter.

A good opportunity of examining the magnetic properties of nickel and cobalt was lately improved by M. Hankel, of the Leipzic Society of Sciences. The bars were very large and pure; that of nickel 168 mm. long, 41·1 broad, and 13·1 thick; that of cobalt, of nearly the same dimensions. A similar

piece of iron was examined along with them. Comparing the iron with the nickel, it was found that within the limits of current-strength used, the magnetism in the former increased proportionally to this strength; the nickel at first, *i.e.*, with weak currents, showed nearly the same magnetic force as the iron; very soon, however, its magnetism increased in less degree than in the iron, so that with the greatest strengths of current it was little over a half of that in the iron. The cobalt behaved like the nickel in that, even with moderate currents, the magnetism increased in less degree than the intensity of current; but it differed in showing a much less strength of magnetism within the strengths of current employed. Since, however, the increase of magnetism from the second last to the last observation, in cobalt, was much greater than in nickel, it is not impossible that with very strong electric currents, the magnetism of cobalt may be greater than that of nickel. Unlike the nickel, the cobalt piece was not without coercive force.

A new method of measuring the speed of waves, and at the same time their exact contours, has lately been invented by Mr. Robert Sabine, and tried with excellent results upon lengths of the Red Sea cable at present in course of manufacture at Enderby's wharf, Greenwich. Mr. Sabine's method consists in sending currents into one end of the cable (the other end being to earth), and at regular intervals testing the potential of some given point in the conductor. This is done by means of a mica condenser, which is kept in connection with the point in question until the right interval has elapsed, when it is discharged through a galvanometer. A rotating time apparatus is arranged to close the circuit of the battery at the end, and after a given interval to separate the condenser and discharge it. The interval may be varied from 0.001 to 2.0 seconds. A similar reading is taken for each interval from 0.001 second upwards until the maximum of the potential due to the position of the point tested is attained. This gives a curve of the exact contour of the wave. The speed is measured by sending two waves of opposite size into the cable, and noticing the intervals at which their neutral point passes two given points in the cable. The difference of the intervals and the distance between the points give the speed.

A proposition is on foot for establishing a regular carrier-pigeon communication throughout the county of Suffolk for police purposes, the head-quarters to be at Ipswich.

Professor B. Sanderson communicated at the recent meeting of the British Association at Glasgow a preliminary note of the results of new experiments made on this subject during the past summer. Dr. Sanderson has investigated in a much more complete manner than he had found possible in 1873, not only the distribution of electrical tension on the surface of the leaf of Dionæa when in the normal state and still forming part of the plant, but all other changes of electrical potential, which, as he had previously discovered, take place in consequence of irritation, whether mechanical or other. In most of these investigations Dr. Sanderson has found it advantageous to use an electrometer constructed for the purpose on the principal of Lippmann's. The most interesting results are that in the normal state of the leaf the effect of irritation is to produce an electrical disturbance, of which the duration as measured by the chronograph is relatively considerable, and that the characteristic of this disturbance is that, the whole of the surface of the leaf as compared with the whole plant, *i.e.*, with the earth, becomes more negative than it was before. As regards the distribution of electrical tension on the leaf surface, Dr. Sanderson confirms and extends his own previous observations. He also finds that the important new observations on this point recorded by Professor Munk are generally correct, but is not able to confirm them in several important particulars. His observations lead him to believe that Professor Munk is entirely in error as to the relation which he supposes to exist between the electrical state of the leaf surface when unexcited and that which is induced in it by irritation. The details will shortly be communicated to the Royal Society.

The Western Union Telegraph Company came into possession and control of all the telegraph lines and business in the Southern States on the 1st of July, 1866. During the ten years since then it has reduced the rate on ordinary messages between New Orleans and New York, Boston and Philadelphia, more than a half (3 dols. 25 cents to 1 dol. 50 cents), and established the night system, the rates for which, between the principal cities, are less than one-fourth the day rate ten years ago. Through extension of the lines and increase of wires, telegraphic facilities throughout the South are fully double what they were ten years ago.

The Report of the Direct Spanish Telegraph Company for the half-year ended 30th June shows that there is a balance to the credit of profit and loss of £2,875; which it is proposed to devote to

the half-yearly dividend on the Ten per Cent. Preference Shares, requiring £2,921, while £46 is taken from the reserve fund, which will then amount to £1,097. There is no dividend on Ordinary Shares. The decrease of traffic on the Barcelona cable, through restoration of the land-lines after cessation of the Carlist war, has been considerably greater than was anticipated. The anticipation of a considerable increase of the traffic over the Lizard cable, when the civil war ceased, has not been realised.

The estimated traffic receipts of the West India and Panama Telegraph Company for the month of July were £4,355 as compared with £3,553, actual receipts for the corresponding period of 1875. The June receipts, estimated to produce £3,661, realised £3,671.

The estimated gross receipts of the Anglo-American Telegraph Company, on 19th ult., were £1,250; 20th, £1,680; 21st, £1,750; 22nd, £1,800; 23rd, £1,520; 24th, £1,510.

The traffic receipts of the Direct United States Cable Company, Limited, at 3s. per word, for week ending 16th September, 1876, were £3,400; 23rd, £3,400.

The Western and Brazilian Telegraph Company have received advices that communication between Rio Grande do Sul and Monte Video is restored, and the cable working well.

The Indo-European Telegraph Company have declared an interim dividend for the half-year ending the 30th June last at the rate of 5 per cent. per annum, free of income-tax.

Electrical Science in Foreign Journals.

COMPTES RENDUS OF PARIS ACADEMY.

No. 7: 14TH AUGUST, 1876.

No papers on electrical subjects.

No. 8: 21ST AUGUST.

An Effect of Lightning during the Storm of 18th August. By M. TRÉCUL.

Electric Regulator, for maintaining the Motion of a Pendulum. By M. BOURBOUZE.

Chaplet Flashes of Lightning. By M. PLANTÉ.

[THE subjects of these three papers have been referred to in our notes, page 248.]

No. 9: 28TH AUGUST.

Sixth Note on Electrical Transmissions through the Ground. By M. DU MONCEL.

HE first studies telluric currents produced by a difference in composition of the liquids in which two plates are immersed. He placed one zinc plate (5 sq. dcm.) in a shallow well in a farm-yard, another in a well on the border of a wood 161 metres off, connecting them by a wire of 2,880 metres resistance; the Breguet galvanometer showed a current of 9° 30′ from the farm-well to the wood-well. Employing a Daniell element he found the resistance of the ground to be 2,989 metres, when the battery current went the same way as the telluric current, and 6,901 metres in the opposite case. M. du Moncel next made a couple with the two liquids and zinc plates, separated by a porous vessel. A current was had, marking at first 80°, and in six hours, 83°; the electrode in the farm-well water being positive. This water contained some traces of sulphuretted hydrogen and products of organic origin. The other was pure. Neither acted on litmus paper. Removing the slight layer of oxide of zinc, he got quite similar effects, slightly stronger. Using other metals, he found the action peculiar to zinc, at least as regards direction of the current, other metals giving a current in the opposite direction. M. Du Moncel next describes experiments on a pond with a bottom of compact clay loam; the greater resistance of the liquid mass in this case is due to the liquid being in some sort isolated by the loamy layer, and the transmission being chiefly by reason of the conductivity proper of the sheet of water. The author compared couples made with diaphragms of clay and of sand; the deflections from the former were weaker. Other experiments were made with electrodes immersed at different points in the deep canal joining Caen with the sea. M. Du Moncel concludes that beyond 336 metres the resistance opposed by the water of a river remains nearly the same, whatever the distance of immersion of the plates; hence this resistance is probably merged in that of the ground at a distance less than 336 metres. From all the experiments it is inferred that, in the best conditions, the resistance of the ground varies from 4 to 5 kilometres of telegraphic wire, so that it is far from being *nil*, as is often said. If reserves of water, such as wells, do not intervene in the communications, it may sometimes constitute an enormous resistance, at least when the electrodes are not largely developed, as in use of water and gas-pipes.

No. 10: 4TH SEPTEMBER.

No. 11: 11TH SEPTEMBER.

No papers on electrical subjects in these two numbers.

ANNALES TÉLÉGRAPHIQUES.

MAY-JUNE, 1876.

Review of the Electrical Apparatus employed in the Working of the French Railways (second article). By M. AMIOT.

THE apparatus described is that for working the block system:—1. Tyer's: 2. Regnault's; 3. Lartigue Tesse and Prudhomme's. Of Tyer's apparatus there are now 135 in use, 109 of these on the line from Paris to Marseilles, and 12 on that from Lyons to Saint Etienne, covering a length of

472 kilometres. The Eastern Railway use Regnault's apparatus on part of the line from Paris to Rouen, and the line to Versailles. It requires two line wires and two district batteries for each station. Advantages:—The agent signalling departure has his signal repeated. He cannot permanently alter, with his keys, the inclination of the repeating needle. Atmospheric discharges cannot bring the needles permanently away from the vertical. In the electro-semaphoric apparatus of Lartigue Tesse and Prudhomme, a single movement with the hand covers the train behind and signals it forward, or announces its arrival and effaces the distant signals which covered it. The signal which covers the train is done mechanically, the other two electrically. This system is used on the line from Saint Denis to Creil, by Chantilly, about 41 kilometres.

Comparative Examination of the Batteries used in Telegraphy. Report of M. Gaugain, on the bichromate of potash batteries, and in particular on the Delaurier battery.—Reserved for separate notice.

Note on M. Ducrétet's Rheotome, with Constant Direction. By M. Cael.

M. Ducrétet lately called attention to the resistance to passage of a current by aluminium forming the positive electrode of a voltameter; and thought the property might be utilised in telegraphy. M. Cael finds from experiment that the stoppage of the fluid by aluminium is not constant every moment, and the metal has not the *rôle* of a completely hermetic valve. Hence he does not see how the liquid rheotome can facilitate the problem of simultaneous transmission, or working of apparatus based on use of two currents. But it might replace with advantage the call by inversion of current used at all stations worked by derivation from the same wire. It would be more economical, and would isolate almost completely the station which had not to receive the call (so that weaker batteries might be used). By interposing the rheotome between the lightning conductor and the line, the consequences of derangement in bobbins of such apparatus would be considerably diminished.

Application of Telegraphy to Meteorology. Extract from a work by M. Bontemps, entitled, *Systèmes Télégraphiques, Aèriens, Electriques, Pneumatiques.*

This traces the history of the subject in France, describes the present organisation, and shows the general characters of European storms.

Telegraphy in Cochin-china and Cambodge. By M. Demars.

Telegraphic Service of New Caledonia. By M. Lemire.

Journal Télégraphique.

No. 20: 25th August, 1876.

General Considerations on Telegraphic Tariffs (continued). By M. Vinchent (of the Belgium Telegraph Service).

Two questions are answered, one relating to proportionality of tariff and cost price, the other to uniformity of tariff. The charges made on the public should not be proportioned to the cost price, where the interest of the majority demands that this proportionality be departed from; but the cost price may be usefully examined as a basis for distribution of those charges among the offices in relation. The uniform charge is of convenient application, but for a large territory, or a line comprising several offices, it becomes either ruinous for the working, or onerous for the near connections; or both. If it is true that, in the case of letters, the service rendered has nearly the same value, whatever the distance, this cannot be said of telegrams; their value, for correspondents, is much greater at a long distance.

On the Theory of Translation. By Dr. Ed. Zetzsche.

He discusses in this first part three cases:—I. The receiver completely withdrawn from the effect of change of electric state produced by the transmitter. II. This effect suppressed in the receiver. III. This effect not suppressed, but measures taken that it may not be injurious, but may even be utilised for the transmission.

Annales de Chimie et de Physique.

August, 1876.

Memoir on the Stratified (Electric) Light. By M. Neyreneuf.

In this instructive paper, after describing some fundamental experiments which prove that negative electricity attracts gases and positive electricity repels them, the author expounds (Chap. I.) his theory of stratification; the two forces at the two ends of a tube are capable of producing nodes and ventral segments, so that the luminous effects of the electricity traversing the layers, condensed or expanded, must be different. The arrangement of the air layers may be entirely destroyed by the mechanical effect of the discharge when strong, but will subsist if this be weak. In Chapter II. the author considers stratifications obtained with the Ruhmkorff coil, the influence of the exterior pole and intensity of current, the constitution of the induced current, the form of the stratifications, and the dark space, &c. In Chapter III. it is shown that in various circumstances of combustion of detonating mixtures, the most important characters of stratification are obtained. Hence the causes producing the two series of phenomena may be assimilated.

Correspondence.

RESISTANCE OF CONDUCTORS.

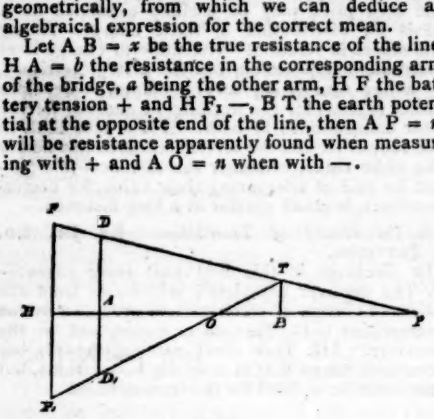
To the Editor of The Telegraphic Journal.

Sir,—I have not seen in any electrical textbooks any explanation of the method of finding the true resistance of a conductor when the readings with + and — currents differ, as is always the case in testing a submarine cable, owing to the difference in earth potential existing at the two ends. The ordinary rule is to take the arithmetical mean of the two results, but this is only

practically correct when the difference is very small.

The following diagram shows the true method geometrically, from which we can deduce an algebraical expression for the correct mean.

Let A B = x be the true resistance of the line, H A = b the resistance in the corresponding arm of the bridge, a being the other arm, H F the battery tension + and H F_1 —, B T the earth potential at the opposite end of the line, then A P = m will be resistance apparently found when measuring with + and A O = n when with —.



Let R_1, R_2 be the resistances observed on the bridge, then

$$m = \frac{b}{a} R_1 \qquad n = \frac{b}{a} R_2$$

$$\frac{m - x}{m + b} = \frac{x - n}{n + b} = \frac{T B}{H F}$$

From which we find

$$x = \frac{b}{a} \cdot \frac{2 R_1 R_2 + a (R_1 + R_2)}{R_1 + R_2 + 2 a}$$

or

$$x = \frac{b}{a} \left\{ \frac{R^1 + R_2}{2} - \frac{(R_1 - R_2)^2}{2 (R_1 + R_2) + 4 a} \right\}.$$

So that when $R_1 + R_2$ is large compared with $R_1 - R_2$

$$x = \frac{b}{a} \cdot \frac{R_1 + R_2}{2}$$

If we take the resistance by deflection, reproducing it through a resistance-box, $a = o$, and so

$$x = \frac{2 R_1 R_2}{R_1 + R_2}$$

By using this expression for the mean, the tests of a cable from day to day will be found to give the same results, though the difference between the measurements with both currents may vary considerably.

F. Jacob.

THE AUTOKINETIC TELEGRAPH.

To the Editor of The Telegraphic Journal.

September 16th, 1876.

Sir,—I notice in your Journal of yesterday's date an account of the Autokinetic Telegraph system, in which you dispose in a summary manner of the claims of the single wire system, on account of the liability of signals sent on them to run together and efface each other.

Permit me to inform you that this objection is purely theoretical, and that no inconvenience whatever is experienced in practice from this cause, or the means possessed by the single wire system for preventing interruption would long ere this have been put into requisition.

The American District Telegraph Company of New York, established in 1871, have thousands of instruments fixed in subscribers' houses connected with the various district offices, and I read now in your issue of yesterday that the system has been extended to San Francisco, &c.

We are informed by the President of the above Company that the danger of signals interfering with each other, in their practice, is about equal to that of an individual being struck with lightning; should such a thing happen, however, a "Fire" signal would never be effaced, but by a special provision would be readable even if a dozen instruments signalled "Messenger" at the same instant.

The system has also been in use by this Company for the last three years without having been found so inconvenient as described by you; on the contrary, it is highly appreciated.

One recording instrument is capable of receiving 1,200 signals per hour, and you will be able to judge from this of the chance of some ten signals per hour (the average number) interfering with each other.

A small sounder was originally placed in these instruments, as a safeguard, to indicate whether the line was occupied or not, but even this has been found unnecessary, and has been discontinued.

I may remark that the risk of interruption of out-door wires is augmented in proportion to the number of spans of wire which run together.

If you would call at this office, I should be happy to show you our single wire system at work, and the arrangements at our disposal for doing precisely the same thing as claimed by the inventor of the Autokinetic system on two wires.

I am, &c.,

W. Henry Davies, Managing Director.

The Exchange Telegraph Company, Limited,
17 *and* 18, *Cornhill, London, E.C.*

[Since penning our article on the Autokinetic Telegraph, we have taken advantage of Mr. Henry Davies' invitation, and have inspected the system referred to in his letter, and we must confess that, ingenious as the Autokinetic system is, the American system carries off the palm for simplicity and compactness. It is true that the latter does not possess the advantage claimed for the former, but at the same time we are assured that practical experience, which after all is the true test of a system, shows that the advantage is purely an imaginary one.—Ed.]

Mr. E. H. Johnson is thanked for his communication.